

## WE CLAIM:

1. A method comprising:  
generating pulses of light in a pulsed source of light, wherein each pulse of light includes at least one photon;  
5 propagating a first pulse of light generated in said pulsed source of light into a first ensemble having a first collective excitation state, wherein photons in said first pulse of light have an energy that can excite said first collective excitation;  
propagating a second pulse of light generated in said pulsed source of light into a second ensemble having a second collective excitation state, wherein photons in said second  
10 pulse of light have an energy that can excite said second collective excitation;  
receiving from said first ensemble and said second ensemble at an interferer for interfering light pulses substantially only photons resulting from generation of said first collective excitation and said second collective excitation; and  
receiving at a first single photon detector and second single photon detector light pulses  
15 from said interferer propagated to said interferer from said first ensemble and said second ensemble.
2. The method of claim 1 further comprising controlling photon detection of said first single photon detector and said second single photon detector with a photo detector controller.
- 20 3. The method of claim 1 further comprising preventing photons not resulting from generation of collective excitations in one of said first ensemble and said second ensemble from reaching said interferer with a first filter disposed between said first ensemble and said interferer.
4. The method of claim 1 further comprising preventing photons not resulting from  
25 generation of collective excitations from reaching said interferer with a second filter disposed between said second ensemble and said interferer.
5. The method of claim 1 wherein an incident photon in a pulse of light generated by said source of light and transmitted into either said first ensemble or said second ensemble has a substantial probability of interacting with the ensemble to generate a collective excitation  
30 in the ensemble.
6. The method of claim 1 wherein said ensemble comprises solid matter.
7. The method of claim 1 wherein said ensemble comprises gaseous matter.
8. The method of claim 1 wherein said ensemble comprises liquid matter.
9. The method of claim 1 wherein said collective excitation of a photon in said

pulses of light interacting with one of the ensembles to generate one of the collective excitations defines a Stokes process.

10. The method of claim 1 wherein each of the ensembles have substantially identical collective excitation energies.

5 11. The method of claim 1 wherein said first ensemble and said second ensemble comprise alkali atoms.

12. The method of claim 1 wherein said first ensemble and said second ensemble comprise Cesium atoms.

10 13. The method of claim 12 wherein a density of Cesium atoms in each one of said first ensemble and said second ensemble is between 1 and 100 atoms per cubic micro meter.

14. The method of claim 1 wherein said preventing photons not resulting from generation of collective excitations in one of said first ensemble and said second ensemble from reaching said interferer comprises a wavelength sensitive first filter disposed between said first ensemble and said interferer.

15 15. The method of claim 1 wherein said source comprises a synchronizer for synchronizing transmission from said source of two pulses.

16. The method of claim 1 wherein said source comprises a laser.

17. The method of claim 1 wherein said source comprises a flash lamp.

20 18. The method of claim 1 wherein said first ensemble and said second ensemble contain molecules each of which has a collective excitation.

19. The method of claim 1 further comprising ceasing generating pulses of light in said pulsed source of light when one of said detectors detects a pulse.

25 20. The method of claim 1 further comprising entangling a third ensemble with a fourth ensemble, each having a collective excitation state, wherein photons in said first pulse of light have an energy that can excite said collective excitation state.

21. The method of claim 20 further comprising entangling said first and second ensembles with said third and fourth ensembles.

30 22. The method of claim 21 wherein said entangling comprises detecting a pulse propagated through a second beam splitter to one of a third single photon detector and a fourth single photon detector.

23. The method of claim 22 further comprising filtering pulses transmitted towards said second beam splitter.

24. The method of claim 21 further comprising entangling said third and fourth ensembles with fifth and sixth ensembles.

25. The method of claim 1 further comprising repeated applications of the steps defined in claim 1 with additional sets of ensembles to provide long distance quantum communication in which resources only scale polynomially with the communication distance.

5 26. The method of claim 1 further comprising repeated applications of the steps defined in Claim 1 with additional sets of ensembles to provide long distance entanglement generation comprising in which resources only scale polynomially with the communication distance.

27. A system comprising:

10 a pulsed source of light for generating pulses of light, wherein each pulse of light includes at least one photon;

a first ensemble into which a first pulse of light generated in said pulsed source of light can propagate, said first ensemble having a first collective excitation state, wherein photons in said first pulse of light have an energy that can excite said first collective excitation;

15 a second ensemble into which a second pulse of light generated in said pulsed source of light can propagate, said second ensemble having a second collective excitation state, wherein photons in said second pulse of light have an energy that can excite said second collective excitation;

receiving from said at

20 an interferer for interfering photons in light pulses received from first ensemble and said second ensemble resulting from generation of said first collective excitation and said second collective excitation; and

a first single photon detector and second single photon detector for receiving light pulses from said interferer propagated to said interferer from said first ensemble and said second ensemble.

25 28. The system of claim 27 further comprising a photo detector controller for controlling photon detection of said first single photon detector and said second single photon detector.

30 29. The system of claim 27 further comprising a first filter disposed between said first ensemble and said interferer for preventing photons not resulting from generation of collective excitations in one of said first ensemble and said second ensemble from reaching said interferer.

30. The system of claim 27 further comprising a second filter disposed between said second ensemble and said interferer for preventing photons not resulting from generation of collective excitations from reaching said interferer.

31. The system of claim 27 wherein an incident photon in a pulse of light generated by said source of light and transmitted into either said first ensemble or said second ensemble has a substantial probability of interacting with the ensemble to generate a collective excitation in the ensemble.

5 32. The system of claim 27 wherein said ensemble comprises solid matter.

33. The system of claim 27 wherein said ensemble comprises gaseous matter.

34. The system of claim 27 wherein said ensemble comprises liquid matter.

35. The system of claim 27 wherein said collective excitation of a photon in said pulses of light interacting with one of the ensembles to generate one of the collective  
10 excitations defines a Stokes process.

36. The system of claim 27 wherein each of the ensembles have substantially identical collective excitation energies.

37. The system of claim 27 wherein said first ensemble and said second ensemble comprise alkali atoms.

15 38. The system of claim 27 wherein said first ensemble and said second ensemble comprise Cesium atoms.

39. The system of claim 38 wherein a density of Cesium atoms in each one of said first ensemble and said second ensemble is between 1 and 100 atoms per cubic micro meter.

20 40. The system of claim 27 further comprising a wavelength sensitive first filter between said interferer and said first ensemble.

41. The system of claim 27 wherein said source comprises a synchronizer for synchronizing transmission from said source of two pulses.

42. The system of claim 27 wherein said source comprises a laser.

43. The system of claim 27 wherein said source comprises a flash lamp.

25 44. The system of claim 27 wherein said first ensemble and said second ensemble contain molecules each of which has a collective excitation.

45. The system of claim 27 further comprising means for ceasing generating pulses of light in said pulsed source of light when one of said detectors detects a pulse.

30 46. The system of claim 27 further comprising means for entangling a third ensemble with a fourth ensemble, each having a collective excitation state, wherein photons in said first pulse of light have an energy that can excite said collective excitation state.

47. The system of claim 46 further comprising means for entangling said first and second ensembles with said third and fourth ensembles.

48. The system of claim 47 wherein said entangling comprises detecting a pulse

propagated through a second beam splitter to one of a third single photon detector and a fourth single photon detector.

49. The system of claim 48 further comprising a filter for filtering pulses transmitted towards said second beam splitter.

50. The system of claim 47 further comprising interferers and detectors for entangling said third and fourth ensembles with fifth and sixth ensembles.

51. The system of claim 27 further comprising means for repeated applications of the steps defined in claim 1 with additional sets of ensembles to provide long distance quantum communication in which resources only scale polynomially with the communication distance.

52. The system of claim 27 further comprising means for repeated applications of the steps defined in Claim 1 with additional sets of ensembles to provide long distance entanglement generation comprising in which resources only scale polynomially with the communication distance.

53. In a system in which ensemble pair L1,R1 is entangled due to excitation of photon generated collective excitations and ensemble pair L2,R2 is entangled due to excitation of photon generated collective excitation, a method comprising:

receiving single photon detection signals from one of a first, second, third, and fourth single photon detectors;

identifying if ensemble pair L1,R1 is entangled with ensemble pair L2,R2 by detecting a photon in any one of said first, second, third, and fourth single photon detectors.

54. The method of claim 53 further comprising transmitting information once ensemble pair L1,R1 is entangled with ensemble pair L2,R2.

55. In a system in which ensemble pair L1,R1 is entangled due to excitation of photon generated collective excitations and ensemble pair L2,R2 is entangled due to excitation of photon generated collective excitation, a method comprising:

receiving single photon detection signals from one of a first, second, third, and fourth single photon detectors;

generating control signal based upon said detection signals;

transmitting said control signals to a secondary control system;

controlling generation of an optical pulse based upon said control signals, wherein said optical pulse is transmitted to ensemble pair R1,L1; and

identifying if an ensemble I1 is entangled with ensemble pair R1,L1 by detecting a photon in either the first single photon detector or the second single photon detector.

56. The method of claim 55 further comprising transmitting information once

ensemble I1 entangled with ensemble pair R1,L1.